An Essay
on
The Circulation.

Respectfully Submitted to the

Faculty,
of the
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By,

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Since the discovery by the illustrious Harvey of the circulation and the movements of the heart the subject has been one of absorbing interest and universal discussion The student is struck with the number and diversity of theories advanced by different speculators on this one subject

In offering a few thoughts myself I shall divide the subject into

II The Foetal Circulation

III The transition changes from Foetal to Adult Circulation

IIII The Mechanism and forces acting to maintain a healthy circulation

First. In taking a general view of the foetal circulation, we observe several peculiarities in the vascular structure. 1 A communication between the auricles of the heart, by means of the foramen ovale; 2 A communication between the pulmonary artery and the descending aorta, by means of the ductus arteriosus; 3 The internal iliacs under the names of hypogastric, and umbilical arteries are continued to the placenta; 4 A communication in the venous system, between the umbilical vein and the inferior cava, by means of the ductus venosus.

In the early weeks of utero gestation what is termed the vascular area makes its appearance in the embryonic mass, and nucleated corpuscles here begin

to form, and push themselves out into the surrounding tissue, seeming to exhibit an affinity for the parts of the mass to which they are tending.

By this means a canal is, as it were constructed through the different portions of the mass, and filled up with these corpuscles or cells, whose extremities adhere; the intervening cell walls becomes broken down, and a communication is established from cell to cell, thus forming a continuous tube or vessel. Such are the primary arteries. By the same process capillaries, and veins are formed; and from the nuclei of the cells which formed the blood vessels, the primary blood corpuscles are formed, and

these circulate through the vessels so constructed. The heart first appears as a simple cavity in a mass of cells, the cavity being formed by the removal of the cells from the center of the mass, and at this early period of its formation contractions may be observed to take place.

Soon however its cavity divides into three compartments, — an auricle, a ventricle, and the arterial bulb; the arterial and venous connections become established, and the heart now bears the form of that of the fish.

As early as the fourth week a septum begins to form in the ventricle, and is completed at the eighth week. The auricular septum remains

imperfect, but the heart may be considered as having four cavities, and as performing its office in the circulatory apparatus.

Without entering into a detail of the various steps in the formation and completion of the ramifying bloodvessels, or of the placenta and its connections with the foetus, we will pass to consider the course and distribution of the blood, to the system of the foetus.

The pure blood is brought from the placenta by the umbilical vein, which passing through the umbilicus enters the liver where it divides into the following branches. two or three distributed to the left

lobe, one which communicates with the portal vein and supplies the right lobe, and the ductus venosus which passes directly backward to join the inferior cava. Thus the liver is supplied with pure blood in large quantities, which fact will account for its great development at birth.

Through the ductus venosus the blood flows into the inferior cava, and is there mixed with the impure blood returning from the lower extremities and abdominal viscera, passing onward into the right auricle. It is by means of the eustachian valve, carried through the foramen ovale into the left auricle,

From the left auricle it passes into the left ventricle, and from thence is forced into the aorta, and distributed to the head and upper extremities, by the carotid and subclavian arteries. Returning through the superior cava to the right auricle, it passes into the right ventricle, and is propelled from thence into the pulmonary artery. In the adult it would now be conveyed to the lungs for purification, but these are nearly impervious and but a small portion is taken to them for the purpose of nutrition, while the greater part passes through the ductus arteriosus into the descending aorta, where

it mingles with that portion of the pure blood, which was not conveyed to the head and upper extremities, and passing through the abdominal aorta, a small portion is distributed to the lower extremities by the external iliacs while the greater part is returned by the hypogastric and umbilical arteries to the placenta. Here by a wise provision of nature a large amount of blood is conveyed to the head and upper extremities, providing for their necessary nourishment; while the lower extremities are supplied with but a small portion of impure blood. Thus retarding their greater development, that the organs necessary to an independ-

ent existence, may be the better provided for. In the placenta, the blood receives a fresh supply of Oxygen from the cecal extremities, and ramifying trunks of the uterine blood vessels, and to them it gives up its carbonic acid, by a process of osmos similar to that carried on in the gill of the fish. Materials for nutrition are also taken up in the same manner, or, by a process of formation of cells which imbibe the nutritious materials, and rupturing liberate their contents in the foetal vessels. An interesting field for investigation here opens to the inquirer, in determining the method, by which the foetus is nourished in utero.

Second. At birth certain changes take place in the mechanism, as well as the course, and distribution, of the blood of the foetus.

With the first inspiration of atmosphere the lung are filled and expanded, and the carbonized blood rushes in to meet the oxygen of the lungs, instead of passing as before through the ductus arteriosus. The communicating duct is of no farther use, and soon shrivels to a mere cord.

The blood having been purified in the lungs, finds its way back to the left auricle through the pulmonary veins, which till now have performed but a small part in the function of the circulation.

Driven on from the left cavities of the heart into the aorta, a part is distributed to the upper, and a part to the lower extremities, passing through the external iliacs; while the blood already arterialized, having no affinity for the oxygen contained in the mothers blood, or having no need of farther purification, ceases to pass into the hypogastric arteries and these too, become useless as a part of the circulatory apparatus, and Nature converts them into ligaments to the bladder.

The blood returning from the lower extremities passes along the ascending cava, receiving in its

course, the now impure blood from the portal system through the hepatic veins, leaving the ductus venosus as the round ligament of the liver. Passing on to the right auricle, it there meets with blood equally as impure, returning from the head and upper extremities; and being no longer fitted to nourish the system, passes through the right ventricle and pulmonary arteries, to the lungs where it is again purified, and prepared to perform another circuit of the system.

The foramen only remains to be closed up, which is done by a membranous layer stretching across it, and the metamorphosis from foetal, to adult circulation is complete

Third. The mechanism and forces of which we shall speak, as acting to maintain a free and healthy circulation comprise under
Mechanism. The heart, arteries, capillaries, and veins.
The heart, situated in the middle mediastinum is composed of four cavities, right and left auricles, right and left ventricles, The right cavities contain venous, the left arterial blood. The substance of the heart is of a dense muscular fibre, disposed in a circular direction around the cavities, and attached to the fibrous rings, surrounding the greater openings. The heart is surrounded by a shut sac, the

pericardium, which is composed of two layers an external fibrous, and an internal serous, which is reflected and covers the external surface of the heart.

The heart is lined internally with a serous membrane, the endocardium, an extension of which forms the lining membrane of all the blood vessels. The structure of the cavities presents several peculiarities.

The Auricles are divided into a principal cavity or sinus, and an appendix auriculae, in the latter are found fleshy columns arranged parallel, and hence called musculi pectinati. Into the sinus of the right auricle open the venae cavae ascendens, and descendens, which return the

impure blood from all parts of the body;
- the coronary vein, which returns
the venous blood from the structure
of the heart itself; its opening being
guarded by the coronary valve; and
the foramina Thebesii, minute pore
like openings into all the cavities,
through which venous blood
transudes directly, without entering
the current of the circulation.
In the right auricle are also found
the eustachian valve, fossa ovalis,
and annulus ovalis, relicts of the
foetal structure, together with the
tuberculum Loweii, a simple
projection into its cavity, between
the openings of the cavae.
Communicating with the right

ventricle, is the auriculo-ventricular opening, surrounded by a dense fibrous ring and guarded by the tricuspid valves, to which are attached the chordæ tendinæ, tendons of thick fleshy columns, the columnæ carneæ, for the purpose of strengthening and sustaining the valves in their position.

From the right ventricle opens the pulmonary artery, to convey the blood to the lungs, the mouth of which is guarded by the semilunar valves, to prevent regurgitation.

Into the left auricle open the four pulmonary veins, returning the pure blood from the lungs. Communicating with the ventricle is the auriculo-ventricular opening, smaller than that

in the right cavities, and guarded by the mitral valves two in number, which are strengthened by cords and muscular columnæ, like the tricuspid. Opening from the left auricle is the aorta, which receives the pure blood from the heart, and distributes it to all parts of the body.

The mouth of the aorta is guarded by the semilunar valves, like those at the mouth of the pulmonary artery.

The arteries are composed of three coats, an external cellular, middle muscular, and an internal nervous, and are elastic to a considerable degree, allowing themselves to be distended by the im-

pulse of the heart, and contracting again immediately that impulse ceases.

The arteries terminate in the Capillaries, which appear like bifurcations of the arteries, though each is as large as the radicle artery from which it springs.

These Capillaries again terminate in the radicles of the Veins, which like the arteries are composed of three coats, though they are much thinner and are supplied with valves, to prevent the reflux of blood. The veins also are somewhat elastic, or distensible, and return the blood from the capillaries, to the right auricle.

Forces. Under this head we shall consider; The action of the heart, Affinity, Capillary attraction, Syphonic action, Muscular Contraction, Suction power of the thorax.

To the action of the heart we shall assign only a sufficient force, by its contractions, to force the blood through the arteries to their capillary terminations, and this it does by spontaneous contractions

What causes the heart to contract, is a question which cannot be answered with certainty, nor will my limits allow me to discuss it here. We only know that at an early period of foetal life,

while the heart is yet an agglomeration of cells, there exist rythmical contractions, and we may infer that nature has endowed this organ with rythmical motions, as a characteristic function.

Certainly no one would attempt to explain, why muscular tissue is more highly endowed with spontaneous contractility, than is yellow elastic tissue; nor do I deem that any multiplication of theories, will be more successful in explaining this phenomena.

Affinity.* Coexistent with the earliest formation of blood corpuscles, we notice that there seems to exist some affinity

*For the thoughts here presented on affinity, I am indebted to an excellent work on Physiology, by Dr. Draper, of New York.

between those corpuscles, and the tissues to be nourished by them. The nuclei of those cells, whose walls form the primary blood vessels, constituting the primary blood corpuscles, circulate through those vessels with no other force to propel them, than what we shall term vital affinity.

By vital affinity we mean, that the circulating fluid contains certain elements, adapted to the accomplishment of certain vital changes in the organic tissues, and that these tissues attract to themselves, fluids bearing such a relation.

If two liquids be allowed to communicate in a capillary tube, the one having a greater affinity for the

substance of the tube than the other, move-
ments of the liquids will ensue; the one
having the greater affinity will be attracted
to, and fill the tube, even to the expulsion
of the other.

So also with what is termed osmose:
a membrane being interposed between two
fluids of different densities, the one hav-
ing the greater affinity for the substance
of the membrane, occupies its pores
and expels the other.

In applying this principle to the
circulation, we may commence with
the simple cell, made up of the
cell wall, the contained fluid,
and the nucleus. This fluid under
the microscope, is observed to pass
in distinct currents to the nucleus,

with which it comes in contact, gives up the nutrient elements, and passes on to give place to other portion of the fluid. The same process takes place in the vegetable cell, the nourishment being transmitted through the cell wall to the fluid, from the fluid to the nucleus.

The blood corpuscles only serve the purpose of carriers to the nutrient elements, and hence, having been driven by the heart action to the systemic capillaries, they appear there laden with oxygen, and a variety of nutrient elements for the reparation of the various tissues, as well as certain effete matters, to be eliminated by excreting organs.

The oxygen has a high affinity for the disintegrating tissue, and is attracted to it; a union takes place and carbonic acid is the result, while in the tissue an affinity is produced for the elements of nutrition, which they absorb and this portion of the blood having lost its affinity for the tissue, is pressed onward into the veins by the approach of other portions of arterial blood.

In like manner blood containing effete matters, as for instance uric acid, has a ~~[illegible]~~ a high affinity for the kidneys, is attracted to them, gives up its urine to the malpighian bodies, and at the same time losing its affinity, is pushed onward to give place

to the constantly approaching masses. The principle or force, of cappillary attraction is here made available, in aiding the onward flow of the blood through the smaller veins.

The blood is also aided in its return to the heart, by the Syphonic action of the blood vessels. Starting from the arch of the aorta, and passing through the upper one half of the body, back to the right auricle, and allowing the whole distribution of vessels, to be represented by a single tube or vessel, we have a simple syphon, whose discharging extremity is some inches lower than its origin. Again, passing from the aortic arch

through the lower one half of the body, to the right auricle, we have in the same manner an inverted syphon, whose mouth is some inches higher than its discharging extremity. The resultant action is the same in both, and tends powerfully to facilitate the return of the venous blood, to the right auricle.

I can but think, that a little importance is attached to this, as an auxiliary force in the circulation.

That the introduction of air into the veins, during surgical operations is followed by instantaneous death, on its arrival at the heart, none will dispute: Why it is so can only be explained, by considering it

as an interruption to the syphonic action of the vessels.

In the larger venous trunks lying contiguous to muscles, another auxiliary force is brought to bear on the flow of blood towards the heart. When a muscle contracts longitudinally it expands latterally, and the yielding walls of the veins are pressed upon to such an extent, as to drive the blood from that portion of the tube; the valves prevent it from retrograding, and it is forced onward towards the heart; being retained thereby valves, when the muscle relaxes, the space can only be filled, by blood from the distal portion of the vein.

The suction power of the thorax is exerted principally upon the venae cavae. When the sternal ends of the ribs are elevated by the inspiratory muscles, and the diaphragm is contracted, enlarging to so great a degree the thoracic cavity, a vacuum is produced. We are reminded at each inhalation of the great suction power exerted on the trachea, to draw in the atmospheric air as one means of filling this vacuum, and there is no reason why this same suction power should not, to the same extent, be exerted on the trunks of the cavae as they enter the thorax, tending very forcibly to draw their fluid contents into the thoracic cavity.

In the pulmonic circulation the force of vital affinity is especially manifest. The venous blood burdened with carbonic-acid, has a high affinity for the oxygen of the lungs, and is strongly attracted to them; an interchange of gases takes place, the affinity is lost, and the approaching venous blood drives it on into the pulmonary veins, and so back to the left cavities of the heart

The beauty of this theory, and its aptness to explain so many heretofore unexplained phenomena in nature, recomend it to every thinking mind. A more perfect presentation of this theory, may be found in the pages of Draper's Physiology.

If in the foregoing pages I may seem to have been guilty of plagiarism, the only plea I can urge is, that with the ground so thoroughly canvassed before me, I find it difficult to consider the subject, without making use of ideas advanced by others to some extent.

I may at least congratulate myself, that though I add nothing to science, I have at least familiarized myself, with some of the past, as well as present theories, on this subject.

Very Respectfully.

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